Cooperative Discrimination Sensor: Detecting and Tracking Human Activity

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The United States has 90,000 miles of coastline, 5,000 miles of intercoastal waterways, and 9,000 miles of land borders. Increasing security concerns and threats along these borders, as well as in urban areas, have forced government infrastructure, secure installations, and border security to consider the need for increased perimeter security solutions. This project reduces to practice several radar devices recently developed at LLNL. These ultra-wideband (UWB) radar systems are used in combination and in a cooperative network environment to provide detection, tracking, and discrimination of human activity.

Figure 1 illustrates the cooperative discrimination sensor (CDS) system.

The first year of this two-year effort focused on combining or fusing existing UWB radar circuits, evaluating interference issues, testing radar performance, and applying signal-processing algorithms to detect, track, and discriminate basic human activity, such as respiration rate. Current sensors were evaluated in a precision test-bed to characterize their performance and determine how they perform in concert for intrusion sensing and characterization in network applications.

Project Goals

Our goal in the second year was to focus on combining the fused sensors into a three-node test-bed network. This test-bed network will be used to evaluate system performance, demonstrate cooperative discrimination in a network setting, and apply advanced signal-processing techniques to test various tracking, detection, and discrimination algorithms.

Relevance to LLNL Mission

From this work the Laboratory will gain a multi-function, integrated radar sensor that is capable of detection, tracking, and discrimination in a single package. The package can be used in a deployable perimeter security network that operates at power levels previously unobtainable by conventional methods. This project has strong potential for antiterrorism, border, and battlefield monitoring, and facility monitoring applications.

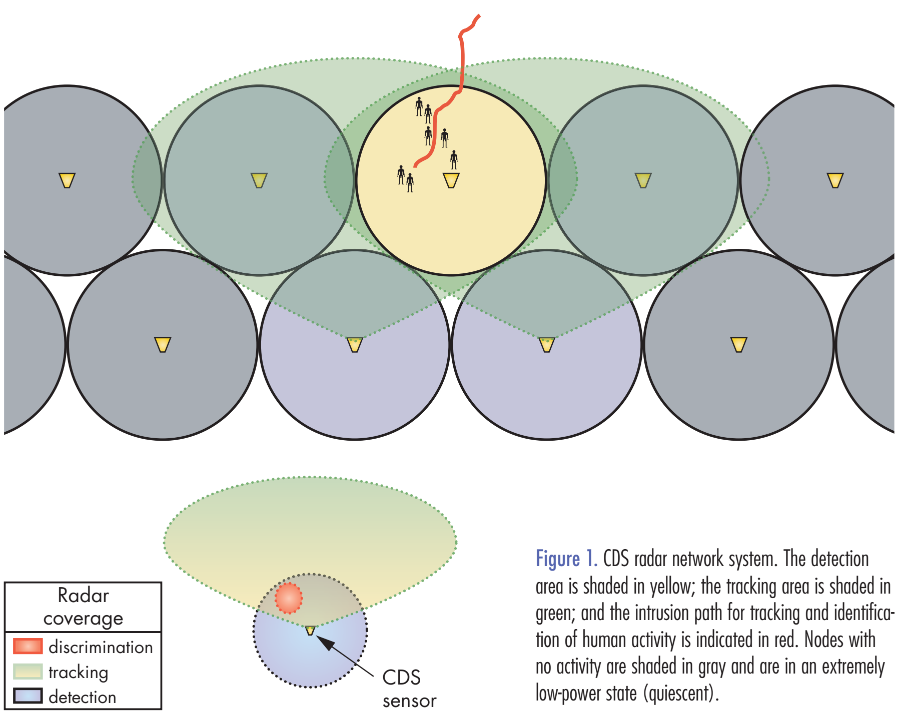

Figure 1. CDS radar network system. The detection area is shaded in yellow; the tracking area is shaded in green; and the intrusion path for tracking and identification of human activity is indicated in red. Nodes with no activity are shaded in gray and are in an extremely low-power state (quiescent).

FY2004 Accomplishments and Results

UWB radar units were evaluated in a precision test-bed to characterize their performance. Radar data was collected over timed intervals and processed to measure interference, efficacy of detection performance, and extraction of respiration signals.

In addition, tracking, or swept-range radar units were used to calculate the position of a target as it was mechanically moved along a known path (see Fig. 2). Position estimation errors were calculated and the overall tracking performance of the radar was determined for each type of target. These tests were repeated using targets with a radar cross-section (RCS) similar to a human target, including mechanical targets and human subjects.

Human discrimination using RCS from radar circuits has been studied with limited results; however, this work led to the idea of using motion artifacts from human activity, such as velocity, breathing, and heartbeat, for discrimination and monitoring.

A brass-board system was assembled and tested with the best performing radar systems. We successfully demonstrated the tracking of a human subject in a complex void (kitchen area) with a high scattering environment, including a metal ladder, water cooler, cabinets, sink, and metal wall. The system tracked the human subject in real-time (30 frames/s) and provided accurate extraction of the subject's respiration rate (0.42 breaths/s) while the subject was motionless (see Fig. 3).

FY2005 Proposed Work

In FY2005 we will integrate the sensor system into a small, low-power package. A network (three) of these sensors will then be used to demonstrate the ability to monitor a large, room-sized area. Finally, we will monitor and tabulate the performance of parameters such as false alarm rates and tracking errors.

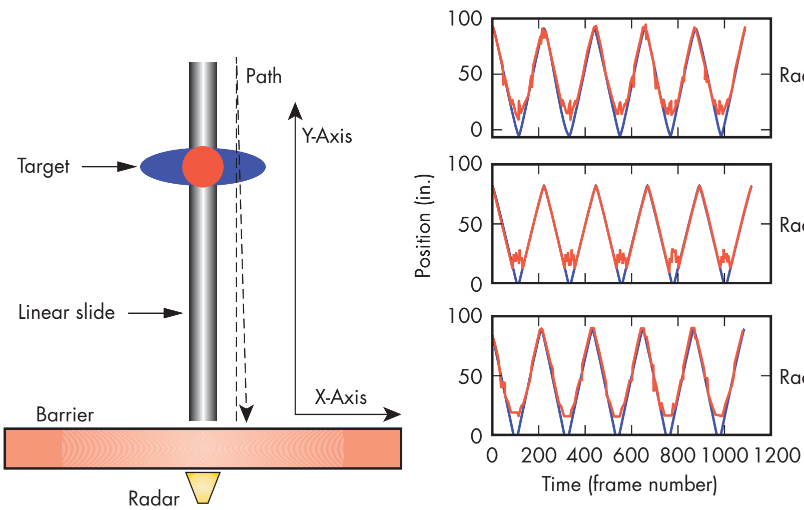

Figure 2. Results from tracking comparison tests, performed using a linear slide and a calibrated target (metal plate) to evaluate the performance of each radar circuit type. Plots indicate known position (blue) and radar-determined position (red).

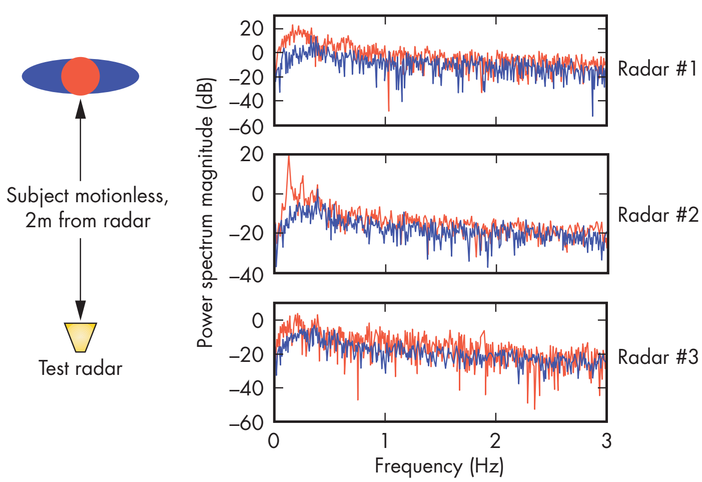

Figure 3. Results of respiration rate comparison tests to evaluate the performance of radar circuit types. Spectral plots indicate background noise (blue) and radar-determined respiration rate (red).